Study of B-decay Electron Cross-Section at High Momentum in pp Collisions in ALICE

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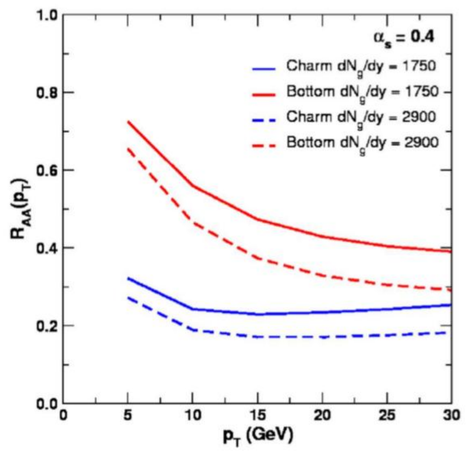
1 Motivation

High-energy heavy-ion collisions at the LHC allow for the study of the properties of the quark-gluon plasma (QGP). Heavy quarks, charm and bottom, produced in the initial hard scattering processes of the collision are excellent probes of the QGP. When heavy quarks traverse the QGP they are expected to lose energy and such energy loss is predicted to be smaller than for gluons and light quarks [1].

On the other hand, experimental data indicate larger energy loss than expected [2]. Heavy flavour production can be studied using electrons from semi-leptonic decays of D and B mesons. The separation of electrons from these two sources (charm and bottom) is of crucial importance to address the expected mass dependence of energy loss. Presented here is the progress towards measurement of electrons from bottom in the transverse momentum range of 7-12 GeV/c in 7 TeV pp collisions using a b-tagging algorithm.

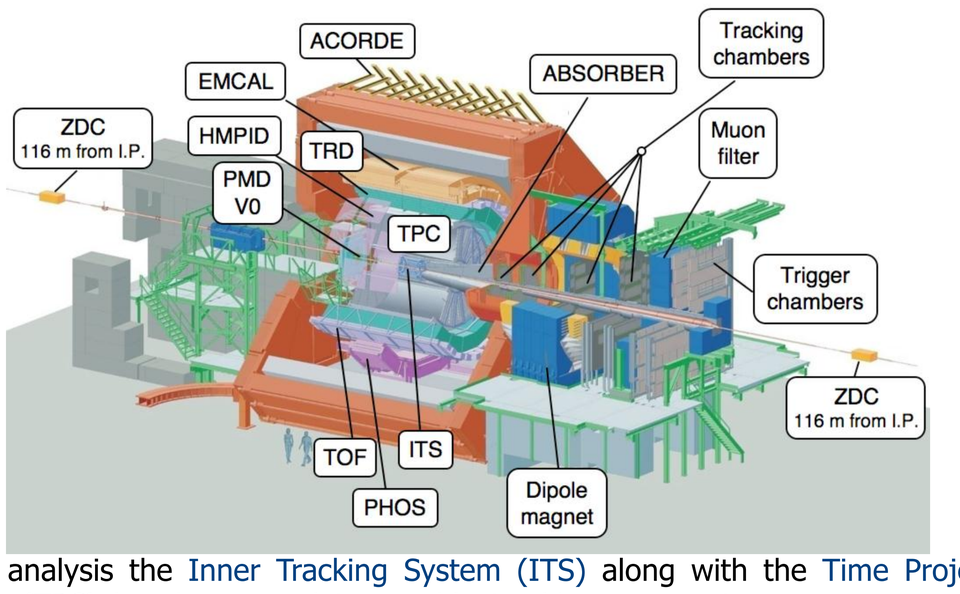


Charm and bottom meson R_{AA}, Wicks and Gyulassy, from [1].

Secondary vertices with an electron and a charged track are reconstructed, and are used to select displaced decay vertices of B mesons. The cross section for bottom-decay electrons is to be compared to FONLL pQCD predictions and it will serve as a reference for studies of B meson suppression in Pb-Pb collisions.

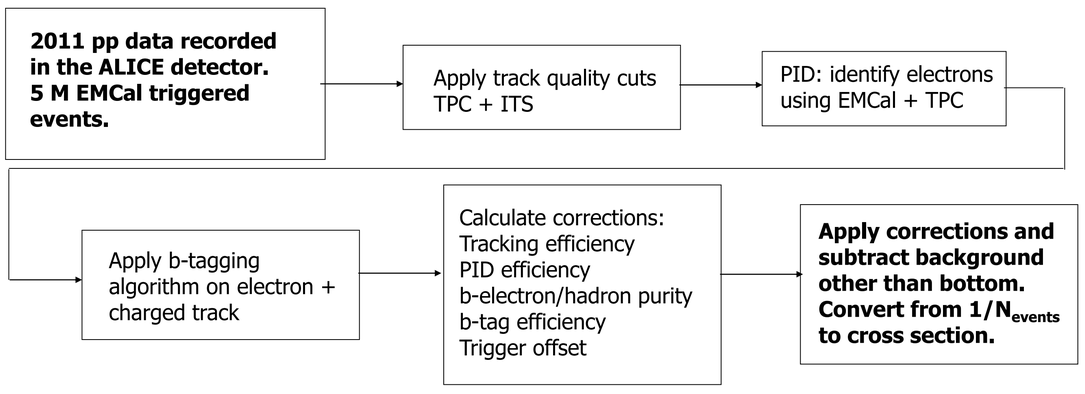
2 The ALICE detector

The ALICE detector is a large multi-component detector located at the LHC, CERN. It is designed specifically to record data with high track-multiplicity of heavy-ion collisions (Pb-Pb) produced in the LHC, but also records pp events.



For this analysis the Inner Tracking System (ITS) along with the Time Projection Chamber (TPC) has been used to provide tracking, momentum measurement and energy-loss per unit length measurement (dE/dx). The TPC along with the Electromagnetic calorimeter (EMCal) allow identification of electrons at low and high transverse momentum respectively. The EMCal is also used as a trigger to increase the momentum range of the measurement.

3 Method



Flowchart of the method to measure the b->e cross section

References:

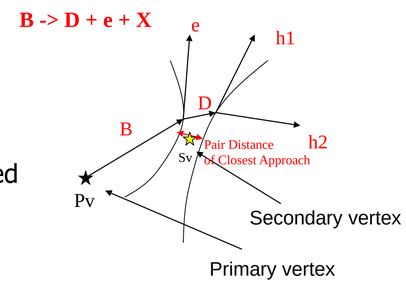
[1] Heavy Ion Collisions at the LHC - Last Call for Predictions, arXiv:0711.0974v1 [hep-ph]

[2] A. Adare *et al.*, PHENIX Collaboration, Energy Loss and Flow of Heavy Quarks in Au+Au Collisions at √s=200 GeV, Phys. Rev. Lett. 98, 172301 (2007)

4 B-tagging electrons

Method:

- ID electron and pair with one hadron
- Calculate pair Distance of Closest Approach (pDCA) to find out if they originate from same point
- Calculate sign-DCA which is the signed distance from primary to secondary vertex, require this distance to be between 100-800 μm.
- Cut on $M_{Inv.}$ (assume kaon mass), p_T of hadron



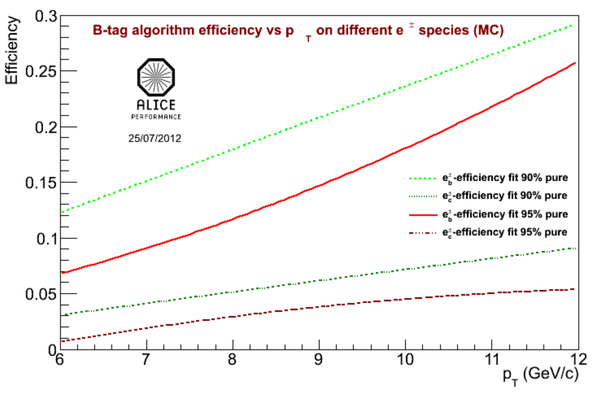
Long life time of B-hadrons (B^+ τ = 1.638±0.011ps)

Decay length of a few hundred μm is resolvable (B^+ cτ = 491 μm)

5 B-tagging efficiency

The efficiencies for tagging a b-electron from a MC sample of electrons is shown in the graph to the right. For two sets of cuts the efficiencies for tagging a b-electron and (mis)-tagging a c-electron from charm (main background) are shown. By performing two measurements along with the knowledge of the respective efficiencies of charm and bottom, shown here, the bottom electron sample can be obtained. Cuts used are:

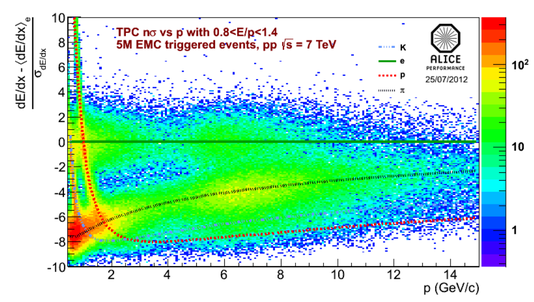
B-tag cuts used		
Cut set	95% pure	90% pure
sDCA (mm)	0.1-0.8	0.05-0.8
pDCA (mm)	0.05	0.1
M_{Inv} (GeV/c^2)	1.7	1.5
$p_{T\text{-hadron}}$ (GeV/c)	1.0	0.7

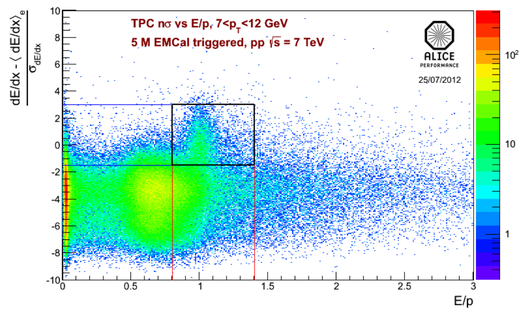


Efficiencies of tagging an electron from bottom/charm as a function of p_T. This is from MC simulations of the ALICE detector. Two different sets of cuts are displayed red are 95% pure cuts, green are 90% pure cuts.

6 Electron Identification

Electrons can be identified through various methods within ALICE. The EMCal and the TPC have been employed in this analysis to ID the high-momentum electrons within the EMCal triggered data set recorded in 2011. Tracks from the TPC are extrapolated to the EMCal and matched with a cluster in the EMCal. The track momentum p and the cluster energy E are used to form the main PID parameter E/p. Electrons deposit much or all their energy in the EMcal, thus E/p around unity is expected for electrons. Hadrons deposit on average less energy, resulting in a lower E/p.



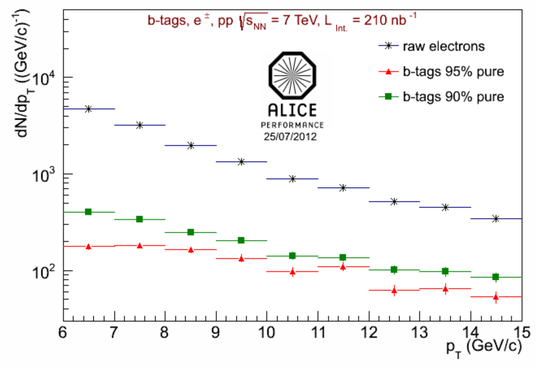


The figure on the left shows energy loss of tracks, in relation to ideal electron energy loss, in the TPC versus momentum. The right figure shows energy loss in TPC versus E/p in EMCal. The data used here are from 2011 pp at √s = 7 TeV triggered with a 4.8 GeV EMCal trigger patch of 4x4 towers (one tower 0.014 in η/φ at η=0).

PID cuts used are: -1.5 σ < dE/dx-<dE/dx> < 3.0 σ and 0.8 < E/p < 1.4

7 Raw electrons and b-tags in 7 TeV pp, conclusions

Using the b-tagging algorithm presented here one can identify electrons from semi-leptonic decay of bottom hadrons. Shown here in the figure are raw electrons along with b-tagged electrons from two different cuts. After subtraction of the estimated background (main source is charm electrons) and acceptance and efficiency corrections, we plan to measure the b → e cross section using this method.



Raw electrons and b-tags on this raw electron sample. 5 M EMCal triggered events is the basis for this figure.

In summary

A direct measurement of b-decay electrons in ALICE can be done by using a secondary vertex algorithm described here. Comparison of b-decay electron production is Pb-Pb and pp collisions, via the nuclear modification factor, is expected to provide insight on b quark interaction with the QGP.